An Experimental Investigation on Bubble Deck Slab

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Abstract- *For decades, several attempts have been made to create biaxial slabs with hollow cavities in order to reduce the weight. Bubble deck slab is a method of virtually eliminating all concrete from the tension zone of a slab, which is not performing any structural function, thereby dramatically reducing structural dead weight. Polypropylene hollow spheres replace the in-effective concrete in the centre of the slab, thus decreasing the dead weight and increasing the efficiency of the floor. By introducing the gaps, it leads to 30 to 50% lighter slab which reduces the loads on the columns, walls and foundations, and of course of the entire building. This paper is to discuss about the various properties of Bubble deck slab.*

Keywords- Polypropylene hollow spheres, concrete, Deflection, Flexural Strength

I. INTRODUCTION

Bubble deck eliminates up to 35% of the structural concrete. When coupled with the reduced floor thickness and facade, smaller foundations and columns, construction costs can be reduced by as much as 10%. With virtually no formwork, no downturn beams or drop heads, and fast coverage of typically 350ft^2 per panel, using Bubble deck means floor cycles up to 20% faster than traditional construction methods. Regardless of project size, shape or complexity;simply shore, place, and pour to quickly install concrete decks.

Most attempts have consisted of laying blocks of a less heavy material like expanded polystyrene between the bottom and top reinforcement, while other types included waffle slabs and grid slabs. In the 1990s, a new system was invented, eliminating the above problems. The so-called Bubble deck technology invented by Jorgen Breuning, locks ellipsoids between the top and bottom reinforcement meshes, thereby creating a natural cell structure, acting like a solid slab. A voided biaxial slab is created with the same capabilities as a solid slab, but with considerably less weight due to the elimination of superfluous concrete. Bubble deck slab is a biaxial hollow core slab invented in Denmark. It is a method of virtually eliminating all concrete from the middle of a floor slab not performing any structural function, thereby dramatically reducing structural dead weight. Bubble deck slab is based on a new patented technique which involves the direct way of linking air and steel. Void forms in the middle of a flat slab by means of plastic spheres eliminate 35% of a slab's self-weight, removing constraints of high dead loads and short spans. Its flexible layout easily adapts to irregular and curved plan configurations. The system allows for the realization of longer spans, more rapid and less expensive erection, as well as the elimination of down-stand beams.

II. MATERIAL AND METHOD

BUBBLE DECK SLAB MATERIALS

The concrete mixture of M20 grade (1:1.5:3) with Ordinary Portland Cement (43 grade) was used. The reinforcing bars of 8mm and 6mm diameter were used in the specimens. Water cement ratio of 0.5 was adopted.

The plastic spheres used in this test are manufactured from recycled plasticwith diameters of 64 mm and 33mm. The purpose of using recycled material is to curb consumption of finite natural resources such as oil and minimize the burden on the environment through the cyclical use of resources, therefore the recycling martial reduces inputs of new resources and limits the burden on the environmentand reduces the risks to human health.

TEST SPECIMENS

Test specimens were designed of four types of beams, two were a conventional R.C beam and the others were Bubble deck beams. The test parameters included the ratio of bubble diameter (B) to slab thickness (H), (B/H). The parameters were as follows, the ratio of bubble diameter to slab thickness were (0.43 and 0.33). Details and dimensions of the test specimens are illustratedin Table .1

Type of beam	Size of beam (mm)	Number of specimens
Conventional	150 × 150 × 750	3
Bubble		3
Conventional	100 × 100 × 500	3
Bubble		3

Table 1. Details and dimensions of specimens prepared

PREPARATION OF SPECIMENS

The prepared beam specimens with M20 grade concrete and 0.5 watercement ratio. Reinforcements were made by using Fe-415 grade steel bars. In 150mm × 150mm × 750mm beams, 8mm diameter bars were used as main bars and 6mm diameter bars were used as stirrups. And in 100mm × 100mm × 500mmbeams, 6mm diameter bars were used as main bars and stirrups. Tie bars were used to tie stirrups with main bars.

64mm diameter polypropylene balls were used in 150mm thick beams and 33mm diameter polypropylene balls were used in 100mm thick beams. These balls were placed in reinforcement cage. This arrangement is called as “Bubble lattice”.

Generally, bubbles are placed in the manner of eliminating all the concretefrom the middle of the slab as shown in fig.1. But in this project, plan to eliminate only theconcrete from the tension zone of the slabs as it has no value in contributing flexural strength of the slab.

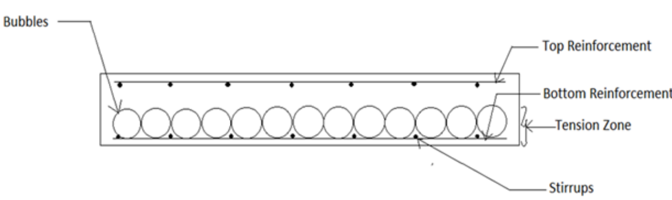

Fig .1. Concept of this project

The specimens as beams (part of slab) and two different depths (150mm and 100mm) were adopted while preparing the specimens as shown in fig.2 to 5.

Fig. 2. Bubble lattice

Fig. 3. Bubble lattice placed in concrete

Fig .4. Pouring of Concrete

Fig.5.Finishing of Surface

After making beam specimens, they were left for curing for 28days atcuring tank.

III. RESULT AND DISCUSSION

The ultimate load capacity and the other results are tabulated in Table .2. The two-way Bubble deck slab with the plastic sphere showed good ultimate load and ductility compared with the solid specimen. The ultimate total loads of solid slabs (SB-1, SB-2 and SB-3) were (48kN, 47kN and 45.5kN) with the deflections of (65mm, 62mm and 68mm). (BB-1, BB-2 and BB-3) specimens showed (40kN, 41kN and 40kN) with the deflections of (120mm, 118mm and 122mm).

The important difference between solid and Bubble deck slabs is stiffness. The stiffness of Bubble deck slabs was slightly changed by the diameter of plastic sphere. As expected, Bubble deck slab showed lower stiffness than solid specimen due to its lower cross section area. On the other hand (BB-1, BB-2 and BB-3) showed a lower ultimate load than the solid specimen by about (10%) dueto reduce of concrete volume by (30% and 25%) due to plastic sphere in Bubbledeck slab specimens.

Crack Patterns

Figure 6. Illustrates the specimens crack patterns and failure mode under ultimate load. All specimens showed flexural failure mode with diagonal flexural cracks. Some small longitudinal cracks appeared in BB specimens. This may be due to relatively thin bottom cover thickness between bottoms of slab to bottom of void. As the thin part of the bottom cover concrete under the void was detached from the plastic sphere, small longitudinal crack occurred.

Fig. 6. Crack pattern

S.No	Beam	Length(mm)	Width(mm)	Depth (mm)	Flexuralload(KN)	Deflection(mm)	UltimateLoad(KN)	FlexuralStrength(N/mm²)
1	SB-1	750	150	150	20.0	65	48.0	6.67
2	SB-2				21.0	62	47.0	7.00
3	SB-3				19.0	68	45.5	6.33
4	SB-4	500	100	100	8.0	-	20.0	6.00
5	SB-5				6.0		18.0	4.50
6	SB-6				7.0		19.0	5.25

Solid beams

S.No	Beam	Length(mm)	Width(mm)	Depth (mm)	Flexuralload(KN)	Deflection(mm)	UltimateLoad(KN)	FlexuralStrength(N/mm²)
1	BB-1	750	150	150	26.0	120	40.0	8.67
2	BB-2				24.0	118	41.0	8.00
3	BB-3				27.0	122	40.0	9.00
4	BB-4	500	100	100	5.0	-	16.0	3.75
5	BB-5				5.0		17.0	3.75
6	BB-6				6.0		18.0	4.50

Bubble deck beams Table. 2. Test Results of beam specimens

IV. CONCLUSIONS

Two-way Bubble deck slabs with plastic sphere voids were tested in two dimensional flexural experiments, the following conclusions can be drawn:-

1. Two-way Bubble deck slabs act like general solid R.C slabs basically and their flexural capacities were good enough to use.
2. The use of plastic spheres in reinforced concrete slabs (B/H=0.43 and 0.33), had a result in comparison with reference solid slabs (without plastic spheres), bubbled slabs has (90%) of the ultimate load of a similar reference solidslab but only (70%) of the concrete volume due to plastic spheres, respectively.
3. The deflections under service load of Bubble deck specimens were higher than those of an equivalent solid slab.
4. The concrete compressive strain of Bubble deck specimens is greater than that of an equivalent solid specimen.

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